Pre-Proposal

Technical Basis for Deep Vadose Zone Remediation by Soil Desiccation

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Introduction

The primary attribute of soil desiccation is the removal of excess moisture from the subsurface, thereby reducing the driving force for downward migration of water and contaminant solutes within the vadose zone and providing a capacity to limit downward migration induced by surface infiltration of water. An expert panel, recently convened by Fluor Hanford, Inc., concluded that soil desiccation could provide significant benefit towards minimizing downward transport of contaminants present in the deep vadose zone. The panel strongly recommended: (1) the development of a multiphase numerical simulator for field-scale modeling, and (2) focused laboratory experiments to demonstrate the technique and to address technical concerns related to the energy balance, osmotic effects, and the potential or remobilization after the desiccation period. The development of a STOMP Water-Air-Energy (STOMP-WAE) mode capable of modeling desiccation is expected to be completed in fiscal year (FY) 2007 through a proposal to be funded by Fluor Hanford, Inc. This project addresses the experimental effort recommended by the panel, including testing and verification of the newly developed simulator. The main objectives of the this project are to answer technical questions raised by the panel, provide a comprehensive data set for numerical testing and verification, quantify key parameters that control the desiccation process, and to demonstrate that desiccation can provide an effective means to prevent contaminant migration to the groundwater.

Proposed Appraoch

A series of one-dimentional (1-D) column and two-dimentional (2-D) flow cell experiments will be performed in the Subsurface Flow & Transport Experimental Laboratory (SFTEL) in the Environmental and Molecular Sciences Laboratory (EMSL). The experiments will be conducted in newly designed and constructed 1-D columns and modified existing flow cells. The columns and flow cells will be heavily instrumented for water content, temperature, water vapor density, and solute concentration measurements. The experiments will be conducted with Hanford Site gravel, sand, and silt sediments. The porous materials will undergo preliminary tests to determine pertinent hydraulic and thermal property values.

After a series of experiments where basic desiccation principles will be demonstrated for the three porous media at various initial water content and injection rates, experiments will be conducted addressing three major concerns raised by the scientific panel in a report prepared by Geomatrix Consultants, Inc. A first concern is related to energy balance considerations as the panel believes that the desiccation front might move considerably slower than that would be expected based on calculations ignoring energy requirements for water evaporation. A second concern is associated with suspected osmotic effects when vapor pressure lowering occurs due to increased salt concentration during soil drying. A third concern is the fear of remobilization of high-concentration solutes after rewetting. These three concerns will be addressed in targeted column experiments.

After completion of the column experiments, two intermediate-scale flow cell experiments will be conducted with a heterogeneous packing. These experiments, which rely heavily on what has been learned during the previous column experiments, investigate soil desiccation after a contamination event with and without surface recharge. The combined suite of column and flow cell experiments will provide the necessary data sets to address the panel's concerns and to test and verify the STOMP-WAE simulator for desiccation purposes. Successful simulations of the experiments will provide confidence that the code may be used for field tests and other applications.

Schedule, Budget, and Deliverable

The proposed project can be completed within a period of two years to address the key concerns related to soil desiccation as a potential remedy for Hanford vadose zone contamination. A formal Pacific Northwest National Laboratory (PNNL) report describing the results will be provided as a deliverable.

The budgetary estimate for this proposed work is $200K.